# Technical Bulletin regarding vertical spacing of horizontal reinforcing for Greenblock ICF walls:

The purpose of this memo is to address the subject of minimum requirements for horizontal reinforcing for either temperature and shrinkage (ACI318) or as lateral reinforcing (ACI318-14.3) as they relate to the particular geometry of the Greenblock Insulated Concrete Form (ICF) system.

## INTRODUCTION:

For experienced concrete design engineers encountering ICFs for the first time, they will find that the design process for ICF does involve additional considerations outside of the criteria normally considered for conventionally poured-in-place concrete walls under ACI 318, particularly chapter 14. References (1) and (2) written and/or co-authored by the Portland Cement Association (PCA) give specific guidelines and recommendations based on testing and research conducted by PCA for ICF systems. Many Building Codes have now incorporated some of these guidelines into the current version of the International Building Code and the Florida Building Code.

One of the primary differences between the design of concrete walls using traditional wall forming systems and ICF forming systems is the amount and spacing of minimum reinforcement perpendicular to the primary reinforcement, or for temperature/shrinkage requirements. This difference is due to the fact that the ICF form manufacturers include an embedded form tie which holds the horizontal reinforcement. ICF forms are manufactured at various heights ranging from 12", 16", 18" and 24". Therefore, the vertical spacing of horizontal reinforcement can vary depending on the ICF form used.

## DESIGNING RIENFORCEMENT FOR ICF CONCRETE WALLS PER ACI318:

Most engineers designing traditional reinforced concrete walls cite the specific requirements of 14.3.3 to calculate the minimum horizontal steel requirement (and then simply specify the bar diameter and vertical spacing to achieve the optimum and specified minimum) which is .02% ratio of steel to concrete area in the vertical section of the wall. A similar ratio of steel reinforcement requirement is often cited for minimum temperature and shrinkage reinforcement from ACI 318 section 7.12. However, this requirement is restricted to structural slabs. Additionally, ACI318 section 14.3.5 requires that "Vertical and horizontal reinforcement shall be spaced no farther apart than three times the wall thickness, nor farther apart than 18 inches." There are some additional considerations which can be taken to relax these requirements.

The first consideration is the fact that in many cases, unreinforced, or plain concrete is capable of resisting forces, especially if the resultant stresses are primarily compressive. ACI318 chapter 22 section 22.6 allows for the design of Plain Concrete walls with certain limitations. The basic limitations are:

1) *If the resultant of all factored loads is located within the middle-third of the overall wall thickness,* - ACI318-22.6.3, and

2) *The provisions for plain concrete walls are applicable only for walls laterally supported in such a manner as to prohibit relative lateral displacement at top and bottom of individual wall elements – ACI318-22.6.3 (Commentary)*

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There are additional limitations specified in ACI318-22.6.6 including a minimum wall thickness of 7 1/2 inches for basement walls. However, for most residential and some commercial projects, these limitations are usually accomplished. In moderate design wind speed areas and seismic zones, the wall cross section is primarily in compression and requires only minimal reinforcement for temperature and shrinkage considerations.

Another consideration is that even the ACI code allows for engineering judgment in the application of the guidelines in the ACI318 code. In fact, section 14.2.7 enables the engineer to consider relaxing strict adherence to this section as follows:

> *"14.2.7 – Quantity of reinforcement and limits of thickness required by 14.3 and 14.5 shall be permitted to be waived where structural analysis shows adequate strength and stability."*

The commentary provided for 14.3 also dictates that the engineer must check the wall to ensure that the appropriate requirements of vertical and horizontal shear have been met by the design. Once the engineer has established adequate strength for the wall, the specifics of Clause 14.2.7 are applicable.

Besides checking for shear adequacy, the wall should also meet flexural requirements as specified in 10.5.1. and 10.5.2 ("Minimum reinforcement of flexural members"). As to exactly how much flexural strength must be provided by either the vertical or horizontal reinforcing, Section 10.5.3 provides the following:

> *"10.5.3 – The requirements of 10.5.1 and 10.5.2 need not be applied if at every section $A_s$ provided is at least one-third greater than that required by analysis"*

Therefore, as long as the horizontal reinforcing is at least 33% greater than that required by structural analysis, the strict adherence to the .02% rule established under 14.3.3 and 10.5.1 may be waived. It should be understood however that the Engineer needs to be careful where some walls span horizontally not vertically depending on the location of intersecting walls and type of loading when considering this calculation.

In reference (3), pages 2 and 3, the author at the Portland Cement Association (PCA) concludes: "Furthermore, based on review of the ACI index, which dates back to 1905, no papers have been published by the Institute which deal specifically with this subject matter (basis for minimum horizontal reinforcing in concrete walls).Therefore, it appears that existing code provisions for minimum quantities of reinforcing steel are based solely on engineering judgment and have no apparent technical basis." Testing performed by PCA for ICF wall systems concludes that, "48" on center spacing for both horizontal and vertical reinforcement is an adequate minimum."

### DESIGNING SPECIFICALLY WITH GREENBLOCK ICF:

The difficulty with ICFs is that the rebar spacing is already preset by the geometry of the wall. Thus, if the engineer strictly adheres to the dictates of 14.3.3, it may end up imposing a diameter of steel reinforcement that is considerably over-safety factored to provide for a temperature condition that in

fact is substantially altered from the conditions of exposed poured concrete that ACI 318's empirical formulae were designed to suit.

As the forms are usually installed as a "block" or form unit assembly, horizontal steel is always locked in first into the system in increments suited precisely to the manufacturer's form unit height. In the case of Greenblock's ICF forming system, this increment is ALWAYS 12 inches. Therefore vertical spacing of the horizontal reinforcing would either be 12", 24", 36", 48" etc.

- In an example of section 14.3.3 calculations, the following could be true:
  For 2 courses of 6"core Greenblock ICF the cross-sectional area is:
  24" x 6" = 144 sq. inches
  144 x .0020 = 0.288 sq.in. minimum rebar area required
- No.5 bar has an area of 0.31sq.in.and meets the requirements of this section
- No.4 bar has a diameter of .20 and does not meet the requirements.

The use of a #5 horizontal reinforcing bar every other course (24" vertical spacing) does meet the requirements of ACI 14.3.3. for 4" and 6" core forms. Although the use of a #5 horizontal reinforcing bar every 2 courses of 8" core Greenblock ICF form does not quite meet this requirement (only 24% less) it would meet the requirements of ACI 318-10.5.3 and is certainly greater than the 48" spacing recommended in the PCA report (ref.3). We recommend the use of #5 every other course so as to ensure proper alignment and horizontal support for the vertical reinforcement which is to be inserted down through the alternating horizontal reinforcing bars.


Questions regarding this technical discussion may be addressed to:

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**References:**

(1) HUD PRESCRIPTIVE METHOD FOR INSULATING CONCRETE FORMS IN RESIDENTIAL CONSTRUCTION 2nd Edition January 2002

(2) Structural Design of Insulating Concrete Form Walls in Residential Construction; NAHB Research Center, Inc., Upper Marlboro, MD; published by Portland Cement Association;1998

(3) Design Criteria for Insulating Concrete Form Wall Systems; by John Roller; 1996 Portland Cement Association; PCA serial no. 2073 (out of print)